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ABSTRACT

This overview describes the development, current role, and implications of computers for computer assisted instruction (CAI), computer managed instruction (CMI), simulation, federally funded CAI systems, disciplinary network CAI systems, micro and mini-computer technology, cost effectiveness, future systems, user groups, computer science curricula, course development, and general funding. An appendix provides a chronological list of PLATO publications. (CMV)

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AN OVERVIEW OF COMPUTERS IN EDUCATION

by

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

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The purpose of this paper is to provide a current overview of a multifaceted issue--Computers in Education. It is intended that the reader be able to derive a general feeling for the state of the art and appreciation for the integral parts. It goes without saying that any of the topics discussed could be expanded into an article if not a book.

Respectfully submitted.

James R. vonFeldt

Growth

Thirty years ago, on a college campus, the first operational digital computer was put into use. During the subsequent years, universities and schools slowly acquired computers primarily for the purpose of research and later for administrative uses. It was only about fifteen years ago that educational institutions first began to support the intensive use of computers for instructional purposes. During the last five years the use of computers has almost doubled. Today academic computing is a billion dollar enterprise.

In the year 1974, it is estimated that universities spent 650 million dollars for academic computing with approximately one-third going for research, one-third going for administrative computing and the rest for instructional uses. As a consequence, all major universities, most colleges and many community colleges now provide computing services to their students through local facilities or through access to off-campus computers. Last year an estimated two million students used a computer in their classes.[1, 2, 3]

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[1] John Hamblen, Inventory of Computers in U.S. Higher Education, 1969-1970 (Washington, D. C.: U.S. Government Printing Office, 1972).

[2] John M. Nevison, "To Know in Part: Publishers, Computers in Instruction and CONDUIT," Association for Computing Machinery, SIGCUE Bulletin, Vol. 8, No. 2, April 1974, pp. 15-19.

[3] Harvey S. Long, "Users of Computers in Education", a presentation made at the Association for the Development of Computer Based Instructional Systems (ADCIS), January 1975.

A recent survey found that for the academic year 1974-75 fifty-eight percent (58%) of all secondary schools had access to computing and spent an estimated 350 million dollars for computing services. Twenty-six percent (26%) of all secondary schools now use computers specifically for instructional purposes.[4, 5]

Focus of CAI

With the rapidly expanding student population of the 1960's and the trend toward individualization of instruction and accountability, early efforts in this field tended to focus on the computer as a medium and primarily upon computer-assisted instruction (CAI). The hope was that the computer could provide individualized learning while meeting the economic necessity of mass instruction. While notable successes have been obtained, the costs of CAI based on large scale time share systems remain relatively high. The advent of mini-computer systems have introduced a dramatic cost reduction of the hardware. In the seventies, as education approaches a "no growth" condition, the emphasis has expanded to include the computer as a tool for problem solving and for management. Computing has been described as a new and fundamental resource in the same sense as reading, writing and mathematics, and thus deserves an equal status in the academic curriculum.[6]

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[4]Charles A. Darby, Arthur L. Korotkin, Tania Romashko, "A Survey of Computing-Activities in Secondary Schools". (Washington, D.C.: American Institute of Research, 1970).

[5]William J. Bukoski, "A Survey of Computing Activities in Secondary Schools (CASE)," (Washington, D.C.: American Institute of Research) 1975.

[6]Arthur W. Luehrmann, "Reading, Writing, Arithmetic and Computing," in Educational Technologies: Productivity in Higher Education. (Eds.) Shelly A. Harrison and Lawarence M. Stolurow, State University of New York, Stoneybrook, New York 1974.

Work in CAI continues to focus on decision models and strategies which use the learner's past performance to decide what new materials to present to optimize learning through Drill and Practice. Another format (technique) is the Tutorial program which presents factual information and permits the student to carry on a conversational question-and-answer dialogue. Controversy still persists over "programmer" versus "learner" control of materials. Programmer-prepared materials use computerized decision models and usually require relatively large amounts of diagnostic testing in order to decide what to present next. Learner control techniques use prepared materials but permit the student the freedom to select the material and the level of explanation and to control the pace of presentation. Much data to date substantiates Tutorial and Drill and Practice under program control. Less data is available on "learner control" of Tutorial and Drill and Practice. It is recognized also that quality control is critical to the validity and effectiveness of any unit of instruction regardless of the technique or strategy chosen.[7,8,9,10.]

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[7] Andrew R. Molnar, Computer Innovation in Education. ERIC Information Analysis Center for Science, Mathematics and Environmental Education, Columbus, Ohio, February 1973. (ED. 077731).

[8] James R. vonFeldt and Marsha Young "Project Skill Summary Report" National Technical Institute for the Deaf, Rochester Institute of Technology, Rochester, New York, November 1974.

[9] James R. vonFeldt "CAI Development Processes and Instructional Effectiveness" Presentation at ADCIS Association for the Development of Computer Based Instructional Systems, January 1975.

[10] William Lee et. al "Report on the Instructional Use of the Computer" Vol. 1, 2, 3. Laboratorie de Pedagogie Informatique, Department of Education, Quebec, Canada, 1973.

Computer Managed Instruction

Computer-managed instructional systems (CMI) have been explored to meet instructional needs as a spin-off of the initial CAI activity. In CMI, the student may take a diagnostic test and on the basis of the results be referred to library reference materials, specific books, to audiovisual materials or a CAI lesson. The principal of CMI is that the computer monitors individual performance, prescribes activity for individuals and maintains records.[11]

Computer Generated Tests

Computer-assisted testing and computer-generated repeatable examination are becoming popular in institutions which have large introductory classes. Some disciplines have developed large question pools which are shared among the departments of a number of universities.[12]

Computer adaptive testing research is concerned with optimizing examinations such that only a minimum number of questions need be asked to obtain the best estimate of learner's skills and knowledge. Computer-based guidance and counseling systems are but a variation of research in testing combined with management.[13]

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[11] John Finch, "An Overview of Computer-Managed Instruction," Educational Technology, July 1972, pp. 46-47.

[12] Gerald Lippey (ed.) Computer Assisted Test Construction Educational Technology Publications, 1974, Englewood Chiffs, N.J.

[13] Martin R. Katz, "Career Decision-Making: A Computer-Based System of Interactive Guidance and Information (SIGI)" Princeton, N.J.; Educational Testing Service, 1974.

Simulations

The "dry" laboratory used in conjunction with a "wet" laboratory is another concept which is meeting widespread acceptance. Many of the non-manipulative, intellectual skills are better taught in a simulated laboratory (dry) or through simulated experiences. Computer-based dry labs are usually cheaper and far more effective than wet labs. Many disciplines such as chemistry, physics, engineering, sociology, psychology and business have developed materials and laboratory courses for real time computer controlled experiments. These courses include programming for data gathering, numerical analysis, modeling, gaming and interfacing of equipment for experiments.[10, 14]

Computer: A Tool

More and more applications are being devised for the use of the computer as a tool in a wide variety of disciplines. Much of the activity in this area can be characterized by Herbert Simon's essay, "The Sciences of the Artificial" in which he discusses the role of artifacts as tools in problem solving and learning. In psychology, for example, computer models and programs have been designed as devices for understanding and studying cognition and learning. In mathematics it has been proposed that computer programs or algorithms be accepted in the same way as mathematical proofs. Thus, the fields of artificial intelligence,

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[10] William Lee et. al "Report on the Instructional Use of the Computer" Vol. 1, 2, 3. Laboratorie de Pedagogie Informatique, Department of Education, Quebec, Canada, 1973.

[14] Lawrence V. Willey, Jr., "Computers and Instructional Productivity", IBM Data Processing Division, Bethesda, Md., 1975.

algorithmic problem solving and cognitive learning are all converging to influence instructional pedagogy and computer applications in education.[15,16]

Computer graphics, computer anamations, computer simulations and computer models are being used to represent complex phenomena which are beyond the limits of human comprehension or for which we lack observable physical models.

Dr. Seymour Papert of MIT is developing new materials for the first to sixth grades in the field of mathematics, physics, biology and music. He seeks to develop new conceptualizations of knowledge based on research in artificial intelligence, heuristics and cognitive learning and to create new learning environments which stress problem solving and creative thinking. The student uses a minicomputer, a computer language called LOGO and various (attached) computer controlled devices. TURTLE, a motor driven device equipped with a pen for tracking and a variety of sensing organs, is one example of student-controlled external devices. Turtle's sensors respond to light, sound and touch as well as simple instructions from the computer. Dr. Papert has demonstrated that average school children are capable of writing programs to draw simple figures, construct complex geometric designs, write a frame by frame movie,

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[15] Herbert A. Simon, The Science of the Artificial, Cambridge, Mass., MIT Press, 1969.

[16] J. D. Fletcher, "Models of the Learner In Computer-Assisted Instruction," NPRDC TR 76-23, Navy Personnel Research and Development Center, San Diego, California, December, 1975.

generate poetry and music, solve motion problems in physics and program the movements of a marionette.[17]

Selected CAI Applications

Dr. Alfred Bork of the University of California at Irvine has developed a number of interactive, tutorial dialogues using a terminal which has special graphic display characteristics. These "dialogues" are used to teach physics. The programs provide the student with helpful hints for problem solving or the student may query the computer in natural language for reasonable approaches to a particular problem. The graphics portion is designed to assist the student in understanding and visualizing concepts and to assist him in developing problem solving skills. The dialogues are used in conjunction with simulations of physical systems; that is, lectures and real experiments.[18, 19]

A highly successful secondary school application of the computer is the Huntington Computer Simulation Materials which were designed to support high school curricula in biology, physics and the social sciences. In biology, the student conducts genetic experiments and learns the statis-

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[17] Seymour Papert, "Uses of Technology to Enhance Education", Artificial Intelligence Laboratory, Cambridge, Massachusetts, June 1973, and "New Educational Technology", General Turtle, 545 Technology Square, Cambridge, Massachusetts 02139.

[18] Alfred Bork, "Current Status of the Physics Computer Development Project", Proceeding of the 1975 Conference on Computers in the Undergraduate Curricula, University of Iowa, Lindquist Center for Measurement, Iowa City, Iowa 52242 (CCUC).

[19] Marian Visch, Jr., and Ludwig Braun, "Computer Simulations as an Educational Tool", Proceedings of the 1974 Conference on Computers in the Undergraduate Curricula (CCUC[6]).

tical nature of Mendel's law. In physics, the student learns to operate a nuclear reactor. Social Science simulations treat the growth and development of an urban area. Simulation permits students to work the systems (manipulate) ideas, materials, or situations which would otherwise not be available to them due to cost, danger or other complexities.

The Educational Management Information System (EMIS) developed at the New York Institution of Technology is a successful example of Drill and Practice through problem solving combined with management of student data. They have demonstrated use of this system with mathematics, Physics and English curriculum. The built-in flexibility of the system allows instructors to adapt existing units to meet their unique needs. This system also includes a process for development of new units.[20]

The Seattle Public Schools have demonstrated success in individualizing instruction and administering it through a comprehensive computer learning management system (LMS). This system, designed for elementary and secondary levels, is now being used also at high school, community college and university levels according to Allan L. Olson, Specialist, Learning Management Systems. This group systematically attended to: 1) curriculum definition, 2) teacher needs and training, 3) student needs,

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[20]"EMIS, Educational Management Information System: An Overview of the System", Designed and Programmed at the Learning Resources Center, New York Institute of Technology, Wheatley Road, P. O. Box 170, Old Westbury, N.Y. 11568.

and 4) parent needs. LMS is unique in its completeness and in its successful implementation.[21,22,23]

One of the most successful CAI applications, on a national basis, is the Stanford Drill and Practice programs in mathematics and reading for elementary school children.[24,25,26,27,28,29] Currently, Dr. Patrick

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[21] Allan L. Olson, "Learning Management System Description Handbook", Planning, Research and Evaluation Department, Seattle Public Schools, Seattle, Washington.

[22] Allan L. Olson, "Can We Individualize In-Service Education of Teachers?", Educational Technology Publications, Englewood Cliffs, N.J. 1974.

[23] Allan L. Olson, "Goals and Objectives For Technical Drawing", LMS, Industrial Arts document, portions reproduced from "Goals In Industrial Education" both available from Seattle Public Schools, Planning, Research and Evaluation Departments, Seattle, Washington, 1972.

[24] Patrick Suppes and Mona Morningstar "Computer-Assisted Instruction", Science, Vol. 166, pp. 343-350, October 1969.

[25] Patrick Suppes, J. D. Feltcher, M. Zanotti, P. V. Lorton and B. W. Searle, "Evaluation of Computer-Assisted Instruction in Elementary Mathematics For Hearing Impaired", technical report No. 200, March 17, 1973.

[26] J. D. Fletcher and Patrick Suppes, "Computer-Assisted Instruction In Mathematics and Language Arts for the Deaf", project No. 14-2280, Final report, Institute for Mathematical Studies in the Social Sciences, Stanford University, Stanford, California 94305, August 1973.

[27] "Evaluation of CAI Math and Reading programs", ESEA Title I, Final Evaluation Report for the 1972-1973 School Years, Department of Government Funded Programs. Board of Education, City of Chicago, Chicago, Illinois.

[28] Linda Culbertson, "CAI-Beneficial Teaching Tool at Texas School for the Deaf", American Annals of the Deaf, February, 1974, pp. 34-40.

[29] Jane E. Mueller, "Burton: A Research and Development Demonstration School Evaluation Report for 1972-73", Cincinnati Public Schools, Program Evaluation, Department of Research and Development, Cincinnati, Ohio.

Suppes of Stanford is conducting research on the uses of audio and natural language processing in computer-assisted instruction. His group is developing a sophisticated method for generating natural speech and applying it to instructional programs for college level logic and tutorial instruction in elementary school mathematics.

Federally Funded CAI Systems

The two current major CAI experiments are the PLATO IV (Programmed Logic for Automatic Teaching Operations) under the direction of Donald Bitzer of the University of Illinois and the TICCIT (Time Shared Interactive Computer Controlled Information Television) developed under the direction of Mr. John Volk of the MITRE Corporation. Special mention should be made of the U.S. Army, U.S. Air Force and U.S. Navy instructional systems.

The PLATO system is a dedicated system controlled by a large computer which drives approximately 450 terminals. A terminal consists of a keyset and a touch sensitive plasma display panel, microfiche slide projector and a random access audio unit. The system serves an elementary school, a community college, the University of Illinois as well as several colleges in Chicago and other states. Tested materials are available for about 1500 instructional hours in fifty disciplines with another 1500 hours in preparation.[30, 31] (See Appendix 1 for extensive bibliography.)

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[30] Elizabeth R. Lyman, "Plato Highlights", Computer-Based Education Research Laboratory, University of Illinois, Urbana, Illinois, 1974.

[31] Elizabeth R. Lyman, "Plato IV Curriculum Materials", CERL Report X-41, No. 1, Computer-Based Education Research Laboratory, University of Illinois, Urbana, Illinois, February, 1974.

The TICCIT system utilizes an intermediate sized computer to serve 128 terminals. The terminal consists of a keyboard, a small color television set to display computer generated displays, video tapes, slides and audio. TICCIT uses cable TV connection to the main computer whereas PLATO utilizes standard telephone lines. TICCIT systems are now being tested at two community colleges using college level mathematics and English curriculum developed at the University of Texas and the University of Brigham Young under the direction of Victor Bunderson. Two other installations of this system are: 1) Buffalo, New York, exploring effects on handicapped students that cannot attend school (the name of this adaptation of the TICCIT system is the Tel-Catch system), and 2) Model Secondary School for the Deaf in Washington, D. C. (The MSSD system will be operable October 1, 1976 for instruction and research.)[32,33]

Learner (student) control is a significant feature of the pedagogy of TICCIT.[34] Both the PLATO and TICCIT field tests are being conducted by the Educational Testing Service at the present time.

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[32] James Marillo, Project director, Associate in Education for the Handicapped, New York State Department of Education. Albany, New York 12234. As of April 1976, 100 students are on-line and being evaluated. Also see "Tel Catch System," Computer Decision, March 1976, pp. 6, 60.

[33] Paul J. Watson, "Design Summary, MSSD Interactive Television System", Proceedings of Summer Conference, Association for the Development of Computer Based Instructional Systems, July 1975. (Implementation of this TICCIT system will be complete October 1, 1976. It will support 60 terminals and 15 video-phones.)

[34] "An Overview of the TICCIT Program," MITRE Corporation, 1820 Dolley Madison Boulevard, McLean, Virginia 22101, January, 1974.

Cost Effect

Research on cost effectiveness of CAI concludes that at the elementary level and with specialized education (disadvantaged, handicapped, nursing, medical, etc.) CAI is cost effective as a supplement to regular instruction. At the secondary and college levels, CAI is as cost effective as traditional education when it is used as a replacement. It can also result in substantial savings of student time.[35,36,37,38,39,40,41] This data DOES NOT reflect the current impact of low cost mini computer applications nor imminent reductions by employment of microcomputer technology. Weston J. Burner, Director of the Computing Center at MIT,

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[35] J. Vinsonhaler and R. A. Bass, "A Summary of Ten Major Studies of CAI Drill and Practice," Educational Technology, July, 1972, pp. 29-32.

[36] Wilber, Schramm, "Big Media, Little Media", Academy for Educational Development, 1924 16th Street, N.W., Washington, D.C. 20036, March 1974.

[37] Dean Jamison, Patrick Suppes, Stuart Wells, "The Effectiveness of Alternative Media: A Survey," Review of Educational Research, Vol. 44, No. 1, Winter, 1974.

[38] Robert J. Sidel, "Current Status of Computer-Administered Instruction Work Under Project Impact," Presentation at U.S. Continental Army Command Training Workshop, Fort Gordon, Georgia, October, 1971, Human Resources Research Organization, 300 North Washington Street, Alexandria, Virginia 22314.

[39] Robert C. Butman, "CAI-There Is a Way to Make It Pay (But Not In Conventional Schooling)," Lincoln Library, MIT, published in Educational Technology, December, 1973, pp. 5-9.

[40] David Mitchel, "Can Computer Simulation Improve the Effectiveness of College Teachings?," Instructional Technology, December, 1973, pp. 14-19.

[41] Roger H. Simonsen and Kent S. Renshaw, "CAI-Boon or Boondoggle?" Note: Mr. Simonsen is manager of systems development technology for Boeing Computer Services, Seattle, Washington; Mr. Renshaw is senior engineer in the Space and Military Applications Division of Boeing Computer Services. Datamation, March, 1974, pp. 92-102.

revealed that in the last 24 months over 200 stand alone mini-computer systems had been implemented for instructional use and research on the MIT campus.[42] Minicomputer systems available now at about 25 percent of the cost of systems 5 years ago are increasingly being used as dedicated instructional systems.

The new growth of instructional computing has been largely justified as an added cost which yields, a "value added" to the students' education as well as increased productivity.[43]

Network CAI Systems

A number of disciplinary groups, particularly in chemistry, physics, medicine and social sciences have proposed, and in fact have implemented, networks to solve problems and to access instruction unique to their disciplines. Work will continue to refine and design networks, to reduce current technical problems, enhance benefits and reduce costs. Some technical alternatives to phone line communications are satellite, microwave, and cable.[44] Minicomputers are becoming popular at the classroom level because of the low purchase price (or even lower rental)

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[42] Weston J. Burner, "Bits, Bauds, and Bucks," Note: Director of Information Processing Center, Massachusetts Institute of Technology, presentation made at the Rochester Area Colleges Fourth Annual Conference on Computers and Instruction, State University of New York, Geneseo, New York, March, 1976.

[43] Lawrence V. Willey, Jr., "Computers and Instructional Productivity," IBM, Data Processing Division, Bethesda, Md., 1975.

[44] Martin Greenberger, et al. (eds.), Networks for Research and Education, Cambridge, Mass.: MIT Press, 1974 (also #42).

and the hardware simplicity and reliability.[45,46] These systems are built so that they can operate on standard 110 circuit without air conditioning. They also have the capacity to communicate with larger systems if and when needed; i.e., networks.

Micro-computer

The newest technology, microcomputer technology, is effecting minicomputers by further reducing costs and phenomenally expanding capacity.

Computer Languages

BASIC is now the dominant interactive language used for instruction in secondary schools. PLANIT and PILOT are fast becoming popular as educators prefer simple, high level languages for instructional development. While batch processing for data processing activities will continue to grow on both large and minisystems, there is a continuing strong trend for more and more interactive computing for instructional purposes.[47]

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[45] Charles S. Tidball, "Using CAI To Teach on a Mini Computer," Office of Computer Assisted Education Services (Medical Center), The George Washington University, Washington, D.C. 20052. Presented at the Winter Conference ADCIS, January, 1976.

[46] Michael J. Fitzpatrick and James A. Howard, "Utilization of Educationally Oriented Microcomputer Based Laboratories," (Fitzpatrick) Department of Electronic Engineering, California Polytechnic State University, San Luis Obispo, Ca., (Howard) Department of Electrical Engineering and Computer Science, University of California, Santa Barbara, Ca. Presented at the Winter Conference ADCIS, January, 1976.

[47] J. M. Nevison, "To Know In Part: Computers In Instruction and CONDUIT," CONDUIT, P. O. Box 388, Iowa City, Iowa 52240.

There is a strong trend toward the use of graphics (particularly for simulations) in all segments of education - probably stimulated in part by the availability of stand alone, low cost, "smart terminals" with graphic capacities.

Cost Appropriations

Another concern on campuses is the appropriate means by which to pay for services. Dartmouth College permits free access by students and faculty for any purpose and considers costs much as they would library costs. Other institutions charge students on the basis of use and time-of-day, type-of-job criterion. MIT has made a commitment to provide alternative resources; i.e., general purpose data processing through large machines, different network systems and dedicated stand alone mini systems. Luehrmann and Nevison's analysis shows that free access may not be more costly than pay as you go and may have significant educational effects.[48]

Future Systems

Innovations combining the computer with other media will be developed. One such system will be a video-disk/CAI system combining the attributes of TV (motion, audio) with CAI (information display, student interaction, data gathering decision making and random access).[49,50]

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[48] A. W. Luehrmann, and J. M. Nevison, "Computer Use Under a Free-Access Policy," Science, May 31, 1974, pp. 957-61. (also 42).

[49] James R. vonFeldt, "A New Possibility In Media: Video Disk-Microcomputer System," Presented at the State University of New York, Stoneybrook, July, 1975.

[50] James R. vonFeldt, "Development of an Innovative Learning Research Technology Prototype: Microcomputer/Video Disk System," Research proposal (draft form), National Technical Institute for the Deaf, Rochester Institute of Technology, February, 1976.

Course Availability

While academic institutions spend over a billion dollars a year on computing, they still function as isolated communities. Instructional programs and applications developed at one location are generally not available for use elsewhere or are difficult to adapt. In most cases a general lack of communications exists accompanied by incomplete documentation and compounded by system and language incompatability.

A major experiment was devised to explore the feasibility of providing transportability through cooperative development and network accessability. Project CONDUIT, a consortium of five regional computer networks with a membership of over 100 colleges and universities, now documents, tests and certifies computer-based instruction materials.[51] A similar effort, sponsored by the National Academy of Engineers, is Project CACHE. The Health Education and Health Science network (Lister Hill project) is again, another approach to provide a common library of instructional materials. A commercial approach to network curricula, development capacity, data processing capacity and administrative data processing is now available by way of the Control Data Corporation (CDC). The instructional components of the CDC system were originated in the PLATO project.

User Groups

As the Federal government has withdrawn its support, private vendors have moved into the creation of user groups to promote libraries of materials. The Hewlett-Packard, Digital Equipment and Wang Laboratories

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[51] "PIPELINE," CONDUIT, P.O. Box 388, Iowa City, Iowa 52240, Fall, 1975, pp. 1-31.

user groups have been the most active. These companies and others have promoted newsletters, seminars, library lists, etc.

Another source of instructional materials is ENTELEK, which catalogs and reports on computer-assisted instruction and computer-managed instruction.[52] The Index To Computer-Based Learning, one of the first clearing houses for CAI materials, is now available in microfich due to the tremendous growth rate of new curricula.[53]

Professional Associations

In addition to user groups and clearing houses, professional associations play an active role in developing communication among computer users through publications, seminars and meetings. Three such groups are:

1. Association for the Development of Computer based Instructional Systems (ADCIS)[54]
2. Association for Educational Data Systems (AEDS)[55]
3. Association for Computing Machinery (ACM)[56]

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[52]ENTELEK, Inc., 42 Pleasant Street, Newburyport, Mass. 01950.

[53]Anastasia C. Wang, "Index to Computer-Based Instruction," Instructional Media Laboratory, University of Wisconsin, Milwaukee, Wis. 53201.

[54]Association for the Development of Computer Based Instructional Systems, P. O. Box 70189, Los Angeles, Ca.

[55]Association for Educational Data Systems, 1201 Sixteenth St., N.W., Washington, D.C. 20036.

[56]Association for Computing Machinery, ACM, Suite 2500, 150 S. Wacker Drive, Chicago, Illinois 60606

Special Interest Groups

A further effort to facilitate communications has been brought about by formation of special interest groups (SIG) especially within the ADCIS and ACM organizations. Interests such as network systems, minicomputer systems and computer languages represent some of the technical areas. Education is represented by higher education, community colleges, elementary and secondary education groups. There is further subdivisions into educational groups such as: Penal Institution Education, Education of Deaf and Handicapped, etc. Finally, there are groups representing specific disciplines such as music, physics, chemistry, engineering, etc.

Computer Literacy

The most frequent exposure to computing in higher education is an introductory course in computing offered as a service course by the computer science or engineering department. This course is usually a course in FORTRAN programming. The second most frequent course is a course in machine and assembly language and file functions.[57]

At the high school level the most frequent courses are introduction to keypunch and programming in BASIC. A number of university courses are being offered in the area of "Computers in Society." These courses are frequently taught as a service course in the computer science departments or jointly with other academic departments. At the elementary-secondary school level courses on "Computer Literacy" are being taught.

[57] Gerald L. Engel, "A Review and Analysis of Curriculum 68," Ph.D. Dissertation, Pennsylvania State University, 1974.

Language skills, computer applications and the history of computing are the most frequently offered courses.[58,59,60,61,62,63]

Computer Science Curricula

The ACM "Curriculum 68" which defined the boundaries of computer science and provided suggested course outlines has had a major impact upon the design of computer science programs in colleges and universities.[64] Similar efforts have been undertaken in information sciences, management sciences and business, junior and community college programs, high school and elementary school programs.[65,66,67,68,69,70,71,72,73,74]

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[58] Proceedings of the Conference on Computers in the Undergraduate Curricula, 1971 and 1974.

[59] E. Horowitz, H. Morgan and A. Shaw, "Computers and Society; A Programmed Course for Computer Scientists", Comm. ACM 15, 4, 1972, pp. 257-61.

[60] P. J. Nicholson, W. R. Franta and R. E. Anderson, "The Impact of a Computer and Society Course on Student Perspectives," Proceedings ACM, August 1973.

[61] Peter G. Lykos, "The Computer Illiteracy Program," American Mathematical Monthly, Vol. 81, No. 4, April 1974.

[62] Charles A. Darbey, Arthur L. Korotkin, Tania Romashko, "A Survey of Computing Activities in Secondary Schools," American Institute of Research, 3301 New Mexico Ave., Washington, D.C., 1970.

[63] William J. Bukoski, "A Survey of Computing Activities in Secondary Schools," American Institute for Research, 3301 New Mexico Ave., Washington, D. C., 1975.

[64] "Curriculum '68: Recommendations for Academic Programs in Computer Science." Comm. ACM, 11, 3, March, 1968.

[65] R. L. Ashenhurst (Ed.) "Curriculum Recommendations for Graduate Professional Programs in Information Systems," Comm. ACM 15, 5, May, 1972.

[66] R. L. Ashenhurst, "Curriculum Recommendations for a Master's Program in Information System Development," Proceedings, ACM, 1972, Annual Conference, 1972.

Primary Instruction: Classroom - Lab

A growing number of schools and colleges are beginning to use the computer in the classroom and laboratory as an integral part of the classroom experience in a wide variety of disciplines. Nationally there are approximately 5,650 modules of computer-based materials currently available for classroom use.[75] This represents a 940 percent increase since 1971.[76] Most of the materials which exist are at the college

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[67] J. D. Couger (Ed.), "Curriculum Recommendations for Undergraduate Programs in Information Systems," Comm. ACM, Vol. 16, No. 12, December, 1973.

[68] Daniel Trichroew, (Ed.), "Education Related to the Use of Computers in Organization," Comm. ACM, Vol. 14, No. 9, September, 1971.

[69] Richard Brightman, "The Computer and the Junior College Curriculum," American Association of Junior Colleges, One Dupont Circle, N.W., Washington, D.C., 1970.

[70] "Recommendations Regarding Computers in High School Education, Washington, D.C., Conference Board on the Mathematical Sciences, 1972.

[71] George Springer, "Report on the Conference on the K-12 Mathematics Curriculum," Mathematics Education Development Center, Indiana University, Bloomington, Indiana, 1973.

[72] Richard Cheng, "Computer Science In Computer Science Education," Monogram, Computer Science Department, Rochester Institute of Technology, 1974.

[73] Richard Cheng, "E.D.P. Management Personnel Education," Proceedings, ACM, Computer Personnel Research Conference, June 1975, p. 40.

[74] Richard Cheng, "Diversified Undergraduate Computer Science Program," Proceedings, ACM, February, 1976.

[75] Beverly Hunter et. al, Learning Alternatives in U.S. Education: Where Student and Computer Meet., (Englewood Cliffs, N.J., Educational Technology Publications, 1975).

[76] James R. vonFeldt, Computer-Assisted Instruction in the Public School General Music Class: A Comparative Study, Doctoral dissertation, University of Missouri, Kansas City, Missouri, 1971, p. 7.

level (see Figure 1). Figure 2 shows that mathematics leads the other disciplines in materials available.

Percentage of Computer-Based Learning Materials by Level of Education.

Level	Percentage
1. College	68.2
2. Secondary	16.3
3. Graduate	9.9
4. Continuing Education	3.4
5. Elementary	2.2

(Hunter, see footnote number 75).

Figure 1

Percentage of Computer-Based Learning Materials by Discipline.

Subject	Percentage
1. Mathematics	26.8
2. Social Science	12.4
3. Business	10.5
4. Education	3.1
5. Chemistry	9.6
6. Physics	9.5
7. Humanities	4.1
8. English	14.3
9. Science	7.6
10. Environmental Science	2.1

(Hunter, see footnote number 75)

Figure 2

Educator's Resistance

As there have been many individual efforts that have explored the use of the computer in education so too has there been a generalized widespread resistance from educators at all levels. Earnest J. Anastasio and Judith S. Morgan's final report on this topic identifies the complex cyclic problem to be a ""people problem."[77] They identify the lack of curriculum and lack of evidence of course effectiveness to skills most instructors do not have. No longer is the question focused upon the effectiveness of the media CAI but upon the effectiveness of specific curricula designed and developed by instructors. Availability of an easy to use, low cost reliable computer system is a fundamental resource requirement.

Successful Course Development

Significant course development has occurred where projects existed that focused upon assisting faculty; that is, provided the faculty with knowledge, skills and experience related to computer-based instruction.[78,79,80,81,82,83] Such programs have the following elements:

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[77] Earnest J. Anastasio and Judith S. Morgan, "Factors Inhibiting the Use of Computers in Education," National Science Foundation, Washington, D.C. 1972. (Available through ERIC Reports, P. O. Box 190, Arlington, Va.), p. 47.

[78] Fred O'Neal, "The Role of the Public Schools in Computer-Assisted Instruction," Educational Technology, March, 1970, pp. 5-10.

[79] Ronald Arnold, "INDICOM: Individual Communications System," Final Report, ESEA Title III Project, Waterford School District, 6020 Pontiac Lake Road, Pontiac, Michigan, 1970.

[80] Kenneth A. Walter, "Authoring Individualized Learning Modules," Project Reflect, CAI Project K-12 Title III, ESEA, Montgomery County Public Schools, Rockville, Maryland, 1972.

1. Extensive orientation to computers used in instruction including several hours experience learning from CAI programs.

2. Identifying the instructional problem or problems to be resolved. This step usually includes formulating objectives, flowcharting the problem, task analyzing, analysis of test instruments and design of the CAI lesson.

3. Writing the unit of instruction with the teacher using a very easy to learn, high level language, such as TACL or PILOT, etc.

4. Evaluating the effectiveness of the instruction as per the declared objectives.

5. Documentation.

Though there are several ongoing programs for faculty now being implemented, the discipline of Education, in general, has not responded in a leadership role. Most programs developed for faculty are supported by computer science or other departments.

Funding

The major Federal funding agencies have been the National Science Association, the U.S. Office of Education and the National Institutes of Health and the Department of Defense. After an early interest in this field, Federal support has continued to decline. Today, academic institutions and the local-state governments are the major source of funding. In 1965, 36% of the funding for computers in higher education

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[81] James R. vonFeldt and Marsha Young, "Project Skill." A summary report, National Technical Institute for the Deaf, Rochester Institute of Technology, Rochester, N.Y., 1973.

[82] James R. vonFeldt, "A Comparison of Two Modes of Developing Computer Assisted Instruction Lessons: 1, Classroom Instructor Development 2, Instructional Programmer-Instructor Development," Proceedings ADCIS Winter Conference, Charleston, S.C., January, 1975.

[83] Fred O'Neal, "Courseware Development Training", Available from Courseware, Inc., P. O. Box 323, Coronado, Ca 92118, 1976.

came from the Federal Government. In 1967, the Federal contribution dropped to 23%, and in 1970 it comprised only 17% of all expenditures for computing.[84,85]

Summary

Over the past 30 years there has been a growth of instructional computer applications in education. A significant increase in the growth rate has occurred in the last five years touching all levels of education, public and private - for normal and for handicapped. Further growth rate can be expected as low cost mini-computer systems are incorporated into the school systems.

The primary implementation has been directed at increasing productivity, meeting individual needs and increasing the quality of instruction. In addition to the techniques of Tutorial, Drill and Practice and Dialogue, continued exploration will be made with Computer-Managed Instruction, Computer Administered Testing, Computer Generated (printed) Tests and Classroom-Lab Simulations.

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[84] John W. Hamblen, Inventory of Computers in U.S. Higher Education, 1969-1970, (Information Systems Consultants, R. R. 1, Box 256A, St. James, Missouri), 1973.

[85] Beverly Hunter, et al., Learning Alternatives in U.S. Education: Where Student and Computer Meet," (Englewood Cliffs, N.J., Educational Technology Publications, 1975).

Computer hardware continues to change. Networks including the PLATO system are extending their capacities to many colleges. The TICCIT system has now become commercially available. Small systems which emphasize low cost, reliability and ease of use are also available now for CAI. A long list of medium to large systems indicate some degree of support for CAI on their general purpose machines. The hardware is now available to meet the unique meeds of educational institutions. We no longer are forced to compromise the resolution of instructional needs by the use of general purpose machines.

Thousands of units of instruction are available through different sources. Networks provide the greatest amount of course material that is constantly usable. Most other materials will require adaptation before it will be usable. CONDUIT has provided materials in psudo-standardized form but the selection is small. User groups, clearing houses and professional associations provide lists of curricula in most disciplines. Mathematics, English, Social Science, Business, Chemistry, Physics and Science have the largest number of curricula available - in that order.

Educators have provided the greatest resistance to the implementation of CAI. So too have educators been the successful implementors and creators of unique applications. The difference between the two groups have been administrative and institutional support which include appropriate hardware, training and development support. Funding is primarily

capital outlay though the nature of the hardware available require only a small percent as compared to even five years ago. The plug-in compatability and "stand-alone" features allow expansion as curricula requires rather than major outlay before curricula is ready. Some NSF funds are available per individual project merit.

Post Script

It is my hope that the information included in this paper may heighten our awareness. The computer is many things to many people. It can be a powerful tool in the process of education - in the hands of faculty: A tool for increased institutional productivity; a tool for individualizing instruction, and a tool for increasing the quality of instruction.

Appendix 1

CHRONOLOGICAL LIST OF PLATO PUBLICATIONS

CHRONOLOGICAL LIST OF PLATO PUBLICATIONS

1. Bitzer, D. L., P. Braunfeld, "Automated Teaching Machine (PLATO)", Patent disclosure (April 6, 1961).

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